RichTek

RT9231A

Advanced PWM and Triple Linear Power Controller

General Description

The RT9231A is a 4-in-one power controller optimized for high-performance microprocessor and computer applications. The IC integrates a PWM controller, triple linear controller as well as monitoring and protection functions into a 28-pin SOP package. The PWM controller regulates the microprocessor core voltage with a synchronous buck converter. The first linear controller supplies the computer system's AGP 1.5V or 3.3V bus power. The second linear controller provides power for the 1.5V GTL bus and the 3rd linear controller provides 1.8V power for the North/South Bridge core voltage and/or cache memory circuits.

The RT9231A features an Intel-compatible, TTL 5-bit programmable DAC that adjusts the core voltage from 2.1V to 3.5V in 0.1V increments and from 1.3V to 2.05V in 0.05V steps. The 5-bit DAC has a typical $\pm$1% tolerance. The first linear controller is user-selectable for output level of 1.5V and 3.3V with $\pm$2.5% accuracy. The other two linear controllers provide fixed output voltages of 1.5V $\pm$3% and 1.8V $\pm$3%. All the three linear controllers drive external N-MOSFET or NPNs bipolar for the pass transistor.

The RT9231A monitors all the output voltages. A power-good signal is issued when the core voltage is within $\pm$10% of the DAC setting and the other levels are above their under-voltage levels. Additional build-in over-voltage protection for the core output uses the lower MOSFET to prevent output voltage above 115% of the DAC setting. The PWM over-current function monitors the output current using the voltage drop across the MOSFET's $R_{DS(ON)}$, which eliminates the need for a current sensing resistor.

Applications

- Full Motherboard Power Regulation for Computer
- Low-voltage Distributed Power Supplies

Features

- **4-in-one Regulated Voltages for Microprocessor Core, AGP Bus, North/South Bridge and/or Cache Memory, GTL Bus Power**
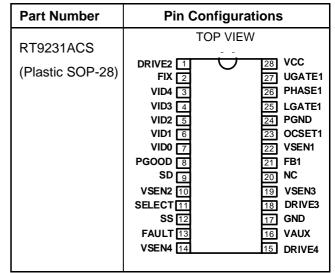- **Compatible with HIP6021A**
- **Power-good Output Voltage Monitor**

Switching section

- **5-bit DAC Programmable from 1.3V to 3.5V**
- **$\pm$1% DAC Accuracy**
- **Fast Transient Response**
- **Full 0% to 100% Duty Cycle Driver**
- **Fixed 200kHz Switching Frequency**
- **Adaptive Non-overlapping Gate Driver**
- **Over-current Monitor Uses MOSFET $R_{DS(ON)}$**
- **Over-voltage Protection Uses Lower MOSFET**

Linear Section

- **Fixed or User-adjustable Linear Regulator Output Voltage**
- **MOSFET and NPN Driving Capability**
- **Ultra Fast Response Speed**
- **Under-voltage Protection**
- **Internal Thermal Shutdown**

Pin Configurations

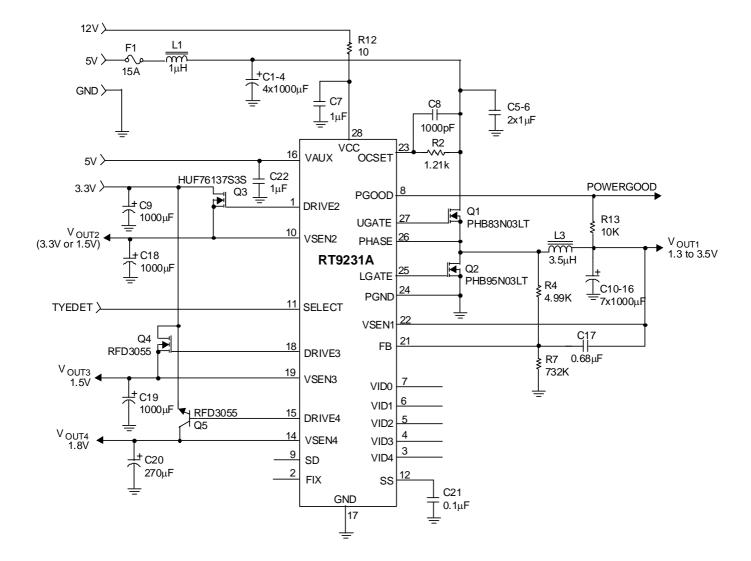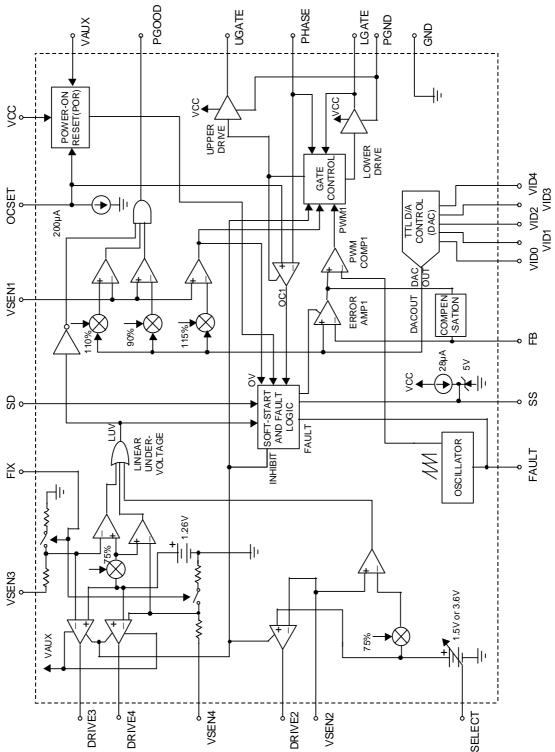| Part Number	Pin Configurations
RT9231ACS (Plastic SOP-28)	TOP VIEW DRIVE2 [1] · · · [28] VCC FIX [2] · · · [27] UGATE1 VID4 [3] · · · [26] PHASE1 VID3 [4] · · · [25] LGATE1 VID2 [5] · · · [24] PGND VID1 [6] · · · [23] OCSET1 VID0 [7] · · · [22] VSEN1 PGOOD [8] · · · [21] FB1 SD [9] · · · [20] NC VSEN2 [10] · · · [19] VSEN3 SELECT [11] · · · [18] DRIVE3 SS [12] · · · [17] GND FAULT [13] · · · [16] VAUX VSEN4 [14] · · · [15] DRIVE4

Ordering Information

RT9231A□ □

└── Package type
S : SOP-28

└── Operating temperature range
C: Commercial standard

Typical Application Circuit

Function Block Diagram

Absolute Maximum Ratings

- Supply Voltage -- +15V
- PGOOD, FAULT and GATE Voltage --- GND−0.3V ~ V_{CC}+0.3V
- Input, Output or I/O Voltage -- GND−0.3V ~ 7V
- Ambient Temperature Range --- 0°C ~ +70°C
- Junction Temperature Range --- 0°C ~ +125°C
- Storage Temperature Range -- −65°C ~ +150°C
- Lead Temperature (Soldering, 10 sec.) --------------------------------- 300°C
- Package Thermal Resistance
  SOP-28, θ_{JA} -- 60°C/W

Recommended Operating Conditions

- Supply Voltage --- +12V±10%
- Ambient Temperature Range --- 0°C to 70°C
- Junction Temperature Range --- 0°C to 125°C

CAUTION:

Stresses beyond the ratings specified in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Electrical Characteristics

(V_{CC} = 12V, PGND = 0V, T_A = 25°C, Unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
VCC Supply Current						
Nominal Supply Current	I_{CC}	UGATE, LGATE, DRIVE2, DRIVE3, and DRIVE4 Open	--	10	--	mA
Power-On Reset						
VCC Rising Threshold		V_{OCSET} = 4.5V	7.5	--	9.5	V
VCC Falling Threshold		V_{OCSET} = 4.5V	7	--	9	V
Rising VAUX Threshold		V_{OCSET} = 4.5V	--	2.8	--	V
VAUX Threshold Hysteresys		V_{OCSET} = 4.5V	--	0.5	--	V
Rising V_{OCSET} Threshold			--	1.25	--	V
DAC and Band Gap Reference						
DAC (VID0-VID4) Input Low Voltage			--	--	0.8	V
DAC (VID0-VID4) Input High Voltage			2.0	--	--	V
DACOUT Voltage Accuracy			-1	--	1	%
Band Gap Reference Voltage	V_{BG}		1.240	1.265	1.290	V

To be continued

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Oscillator						
Free Running Frequency			180	200	225	kHz
Ramp Amplitude	ΔV_{OSC}		--	1.9	--	V_{P-P}
Linear Regulators (OUT2, OUT3, and OUT4)						
VSEN2 Regulation Voltage		SELECT < 0.8V	1.462	1.500	1.538	V
VSEN2 Regulation Voltage		SELECT > 2.0V	3.500	3.600	3.700	V
VSEN3 Regulation Voltage			1.455	1.500	1.545	V
VSEN4 Regulation Voltage			1.746	1.800	1.854	V
Under-Voltage Level (All Linears) (VSEN/VREG)		VSEN3 Rising	--	75	--	%
Under-Voltage Hysteresis (All Linears) (VSEN/VREG)		VSEN3 Falling	--	100	--	mV
Output Drive Current (All Linears)		VAUX = 5V	20	40	--	mA
Synchronous PWM Controller Error Amplifier						
DC Gain			--	65	--	dB
PWM Controller Gate Driver						
UGATE Source	R_{UGATE}	VCC = 12V VCC-V_{UGATE} = 1V	--	4	7	Ω
UGATE Sink	R_{UGATE}	V_{UGATE} = 1V	--	3	7	Ω
LGATE Source	I_{LGATE}	VCC = 12V, V_{LGATE} = 2V	--	1	--	A
LGATE Sink	R_{LGATE}	V_{LGATE} = 1V	--	2	6	Ω
Protection						
V_{OUT1} Over-Voltage Trip		VSEN1 Rising	112	115	124	%
FAULT Souring Current		V_{FAULT} = 8V	10	14	--	mA
OCSET1 Current Source	I_{OCSET}	V_{OCSET1} = 4.5V	170	200	230	μA
Soft-Start Current	I_{SS}	V_{SS} = 1V	--	28	--	μA
Power Good						
V_{OUT1} Upper Threshold		VSEN1 Rising	108	--	112	%
V_{OUT1} Under Voltage		VSEN1 Rising	87	--	95	%
V_{OUT1} Hysteresis (VSEN1/DACOUT)		Upper/Lower Threshold	--	2	--	%
PGOOD Voltage Low	V_{PGOOD}	I_{PGOOD} = -4mA	--	--	0.5	V

Functional Pin Description

DRIVE2 (Pin 1)

Connect this pin to the gate of an external MOSEFT. This pin provides the drive for the AGP regulator's pass transistor.

FIX (Pin 2)

Grounding this pin bypasses the internal resistor dividers that set the voltage of the 1.5V and 1.8V linear regulators. This way, the output voltage of the two regulators can be adjusted from 1.3V up to the input voltage (+3.3V or +5V) by way of an external resistor divider corrected at the corresponding VSEN pin. The new output voltage set by the external resistor divider can be determined using the following formula:

$$V_{OUT} = 1.265V \times (1+ \frac{R_{OUT}}{R_{GND}})$$

Where R_{OUT} is the resistor connected from VSEN to the output of the regulator, and R_{GND} is the resistor connected from VSEN to ground. Left open, this pin is pulled high enabling fixed output voltage operation.

VID0, VID1, VID2, VID3, VID4 (Pin 7, 6, 5, 4, and 3)

VID0-4 are TTL-compatible the input pins to the 5-bit DAC. The state logic of these five pins program the internal voltage reference, DACOUT. The level of DACOUT sets the microprocessor core converter output voltage, as well as the corresponding PGOOD and OVP thresholds. Table 1 specifies the DACOUT voltage of 32 combinations of VID levels.

PGOOD (Pin 8)

PGOOD is an open collector output used to indicate the status of the PWM converter output voltage. This pin is pulled low when the synchronous regulator output is not within ±10% of the DACOUT reference voltage, or when any of the other outputs are below their under-voltage thresholds.

SD (Pin 9)

This pin shuts down the entire IC. A TTL-compatible, logic level high signal applied at this pin immediately disables all outputs. When re-enabled, the IC undergoes a new soft-start cycle. Left open, this pin is

pulled low by an internal pull-down current source, enabling operation.

VSEN2 (Pin 10)

Connect this pin to the output of the AGP linear regulator. The voltage at this pin is regulated to the level pre-determined by the logic-level status of the SELECT pin. This pin is also monitored for under-voltage events.

SELECT (Pin 11)

This pin determines the output voltage of the AGP bus switching regulator. A low TTL input sets the output voltage to 1.5V while a high input sets the output voltage to 3.6V. When the input voltage is 3.3V, DRIVE2 continuously turn on providing a DC current path from the input(+3.3V_{IN}) to output (V_{OUT2}) of the AGP controller.

SS (Pin 12)

Connect a capacitor from this pin to ground. This capacitor, along with an internal 28μA (V_{SS}>1V) current source, sets the soft-start interval of the converter.

FAULT (Pin 13)

This pin is low during normal operation, but it is pulled to 8V (V_{CC} = 12V) in the event of an over-voltage or over-current condition.

VSEN4 (Pin 14)

Connect this pin to the output of the 1.8V regulator. This pin is monitored for under-voltage events.

DRIVE4 (Pin 15)

Connect this pin to the gate of an external MOSEFT. This pin provides the drive for the 1.8V regulator's pass transistor.

VAUX (Pin 16)

This pin provides boost current for the two linear regulator output drives in the event bipolar NPN

transistors (instead of N-channel MOSFETs) are employed as pass elements. The voltage at this pin is monitored for power-on reset (POR) purpose.

GND (Pin 17)

Signal ground for the IC. All voltage levels are measured with respect to this pin.

DRIVE3 (Pin 18)

Connect this pin to the gate of an external MOSEFT. This pin provides the drive for the 1.5V regulator's pass transistor.

VSEN3 (Pin 19)

Connect this pin to the output of the 1.5V linear regulator. This pin is monitored for under-voltage events.

FB (Pin 21)

This pin is connected to the PWM converter's output voltage.

VSEN1 (Pin 22)

This pin is connected to the PWM converter's output voltage. The PGOOD and OVP comparator circuits use the signal to report output voltage status and for over-voltage protection.

OCSET (Pin 23)

Connect a resistor from this pin to the drain of the respective upper MOSFET. This resistor, an internal 200μA current source, and the upper MOSFET on-resistance set the converter over-current trip point. An over-current trip cycles the soft-start function. The voltage at this pin is monitored for power-on reset (POR) purpose and pulling this pin low with an open drain device will shut down the IC.

PGND (Pin 24)

This is the power ground of UGATE. Tie the synchronous PWM converter's lower MOSFET source to this pin.

LGATE (Pin 25)

Connect LGATE to the PWM converter's lower MOSFET gate. This pin provides the gate drive for the lower MOSFET.

PHASE (Pin 26)

Connect the PHASE pin to the PWM converter's upper MOSFET source. This pin represents the gate drive return current path and is used to monitor the voltage drop across the upper MOSFET for over-current protection.

UGATE (Pin 27)

Connect UGATE pin to the PWM converter's upper MOSFET gate. This pin provides the gate drive for the upper MOSFET.
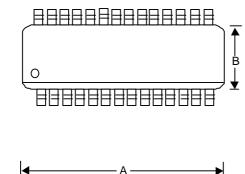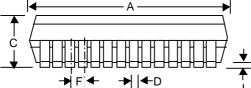
VCC (Pin 28)

Provide a 12V bias supply for the IC to this pin. This pin also provides the gate bias charge for all the MOSFETs controlled by the IC. The voltage at this pin monitored for power-on reset (POR) purpose.
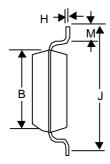
Table 1. VOUT1 Voltage Program

Pin Name					Normal OUT1 Voltage
VID4	VID3	VID2	VID1	VID0	DACOUT
0	1	1	1	1	1.30
0	1	1	1	0	1.35
0	1	1	0	1	1.40
0	1	1	0	0	1.45
0	1	0	1	1	1.50
0	1	0	1	0	1.55
0	1	0	0	1	1.60
0	1	0	0	0	1.65
0	0	1	1	1	1.70
0	0	1	1	0	1.75
0	0	1	0	1	1.80
0	0	1	0	0	1.85
0	0	0	1	1	1.90
0	0	0	1	0	1.95
0	0	0	0	1	2.00
0	0	0	0	0	2.05
1	1	1	1	1	2.00
1	1	1	1	0	2.10
1	1	1	0	1	2.20
1	1	1	0	0	2.30
1	1	0	1	1	2.40
1	1	0	1	0	2.50
1	1	0	0	1	2.60
1	1	0	0	0	2.70
1	0	1	1	1	2.80
1	0	1	1	0	2.90
1	0	1	0	1	3.00
1	0	1	0	0	3.10
1	0	0	1	1	3.30
1	0	0	1	0	3.30
1	0	0	0	1	3.40
1	0	0	0	0	3.50

Package Information

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	17.704	18.110	0.697	0.713
B	7.391	7.595	0.291	0.299
C	2.362	2.642	0.093	0.104
D	0.330	0.508	0.013	0.020
F	1.194	1.346	0.047	0.053
H	0.229	0.330	0.009	0.013
I	0.102	0.305	0.004	0.012
J	10.008	10.643	0.394	0.419
M	0.381	1.270	0.015	0.050

RichTek

RICHTEK TECHNOLOGY CORP.

Headquarter

5F, No. 20, Taiyuen Street, Chupei City

Hsinchu, Taiwan, R.O.C.

Tel: (8863)5526789 Fax: (8863)5526611

RICHTEK TECHNOLOGY CORP.

Taipei Office (Marketing)

8F-1, No. 137, Lane 235, Paochiao Road, Hsintien City

Taipei County, Taiwan, R.O.C.

Tel: (8862)89191466 Fax: (8862)89191465

Email: marketing@richtek.com